

EVALUATION OF SEDIMENT REMOVAL OPTIONS AND BENEFICIAL USE OF DREDGED MATERIAL FOR ILLINOIS RIVER RESTORATION: PRELIMINARY REPORT

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ABSTRACT

The overall habitat quality of the Illinois River is significantly degraded by over 100 years of sediment accumulation. Once-deep backwaters and side channels have lost well over 70 percent of their water storage capacity and in many areas average about a foot deep. A twenty-year restoration project by the State of Illinois and Army Corps of Engineers is being planned to address this problem. The Illinois Department of Natural Resources is evaluating methods of restoring habitat diversity by removing sediment to create a variety of water depths and elevations on the floodplain and islands. Numerous agencies and private companies have cooperated in this effort. This paper provides an overview of the work in progress and preliminary results.

Potential large scale beneficial uses of the sediment include landscaping soil and island formation. For these purposes it is best to add as little water as possible during dredging. The Dry Dredge™ completed a small pilot island in two feet of water by filling a ring of geotextile tubes and then pumping sediment at *in situ* moisture content into the ring. The Dry Dredge™ and a conventional clamshell also piled sediment at various elevations on an existing island where consolidation and erosion were observed. The transport of freshly excavated sediment on conventional conveyor belts was demonstrated.

Sediment cores six feet in length were taken with a vibracore and analyzed for a variety of chemical and physical parameters. Plant growth in sediment was compared to that of native topsoil in greenhouse tests, and field tests with corn and soybeans are underway. Prior dredged material placement sites were investigated to determine the agronomic properties of the sediment after years of weathering. Additionally, clamshelled sediment at *in situ* moisture content was trucked to a former industrial site where the progress of soil formation is being monitored along with the appearance of plants. The potential exists for unloading sediment from barges directly onto brownfields and farmland with slurry pumps.

Keywords: dredging, beneficial uses, conveyor, positive displacement pump, ecosystem restoration, Illinois River.

INTRODUCTION

The Illinois River basin comprises 32,081 square miles stretching from Chicago to Grafton, Illinois, near St. Louis. The watershed is 80 percent agricultural and includes the bulk of the Chicago metropolitan area. The river has undergone numerous changes over the years. The Illinois River itself is 272 miles long and begins southwest of Chicago near Joliet where its two major tributaries join. Historically much of the Chicago area drained into Lake Michigan. However, in 1900 a canal was completed which diverted most of the city's drainage, including sewage, to the Illinois River tributaries, in order to protect Lake Michigan as a source of drinking water. The combined system supports a 327-mile long nine-foot navigation channel, known as the Illinois Waterway, connecting the Mississippi River with Lake Michigan (Mills et al. 1966). Figure 1 shows the location of the watershed while Figure 2 is a profile of the river showing navigation dams and its slight fall from the Peoria Pool to the Mississippi.

The floodplain of the lower 220 miles includes approximately 333,000 acres. Much of it was marshland and backwater lakes in the late 1800s. The river valley supported abundant wildlife resources and was a major recreational hunting and fishing area. It was also one of the nation's top commercial fishing rivers and center of a thriving button industry based on mussel shells. (Talkington, 1991; Belrose et al., 1983).

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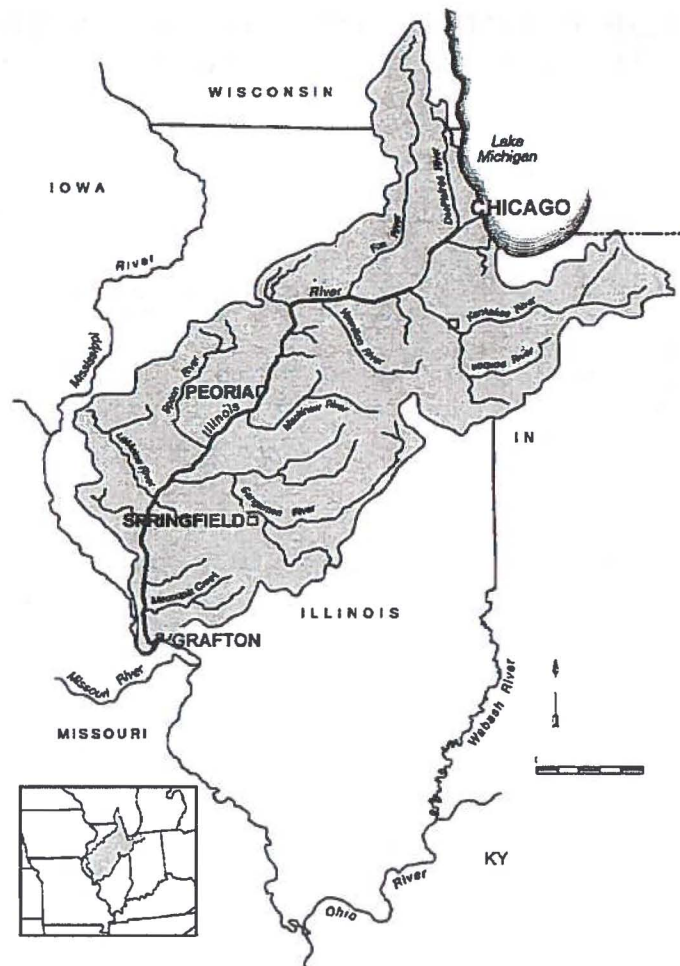


Figure 1. Illinois River drainage basin. Source: Illinois State Water Survey.

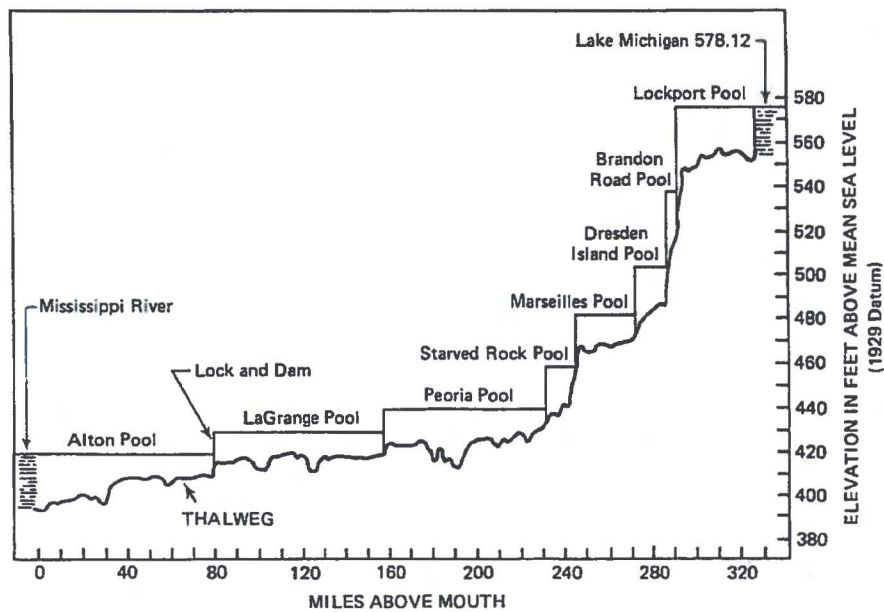


Figure 2. Profile of the Illinois River and Waterway from Chicago to the Mississippi River near Grafton, Ill. From Demissie and Bhowmik, 1986.

Human activities have dramatically altered the physical and chemical environment of the river and its floodplain. The diversion of water from Lake Michigan raised the river's level by as much as seven feet and inundated thousands of acres of floodplain. The amount of water discharged varied, but it averaged 7,222 cubic feet per second until 1939 when it was capped at 3,200 cfs. By 1929 a series of 38 drainage and levee districts occupied 56 percent of the floodplain of the lower 220 river miles. The navigation dams approximately doubled the area of lakes and backwaters in the valley to a total of 67,693 acres in 1969 (Belrose et al., 1983). These collective changes in conjunction with altered drainage practices dramatically altered the river's hydrology resulting in slack water pools and an increase in water level fluctuations. Frequent fluctuations prevent the establishment of native plants on floodplains and disrupt the life cycles of other organisms as well.

According to the Illinois State Water Survey, 13.8 million tons (MT) of sediment are delivered to the river valley annually from tributary streams. Of this 5.6 MT are carried to the Mississippi River while 8.2 MT are deposited in the valley including the floodplain and backwater and side channel lakes. Additional sediment is derived from stream banks and bluffs. Much of this sediment settles in backwater lakes, which by 1990 lost an estimated average 72 percent of their storage capacity (Demissie et al 1992). In 1982 the Illinois Natural History Survey estimated the average depth in the backwaters in the two lower navigation pools at 2.0 and 1.8 feet respectively. The scientists stated "Because sedimentation fills in deep water at a faster rate than it fills in shallow water, bottom land lakes now are uniform, platter-shaped basins that have a low volume to surface area" (Belrose et al., 1983). Figure 3 shows backwaters near Lacon, Il., north of Peoria.

Lower Peoria Lake and Upper Peoria Lake cover 2,582 and 9,239 acres respectively along a 20-mile section of the river. Unlike most backwaters they are not separated from the main channel by islands. The diversion and navigation pools inundated the original islands. The navigation channel passes through the lakes. The current is sluggish through the lakes and seldom exceeds two feet per second. Between 1976 and 1985 the lakes accumulated sediment at a rate of 2,033 acre-feet per year. Comparison of 1903 and 1985 profiles shows that the lakes accumulated about 82,000 acre-feet of sediment during that time, while average depth based on the current navigation pool elevation decreased from 7.6 to 2.0 feet (Demissie and Bhowmik, 1986). Figure 4 illustrates the loss of depth in the Peoria Lakes.

The backwaters today are shallower than in 1980. Frequent water level fluctuation regularly flood and expose large mudflats. Deep water is limited to the navigation channel and marina access areas. Willows thrive in the unstable floodplain and have replaced many other tree species. In general the river valley lacks the aquatic and terrestrial habitat diversity that once produced legendary numbers of fish, waterfowl, mussels and other flora and fauna. Sedimentation is also a problem on the Upper Mississippi River where "Backwater lakes are becoming shallower

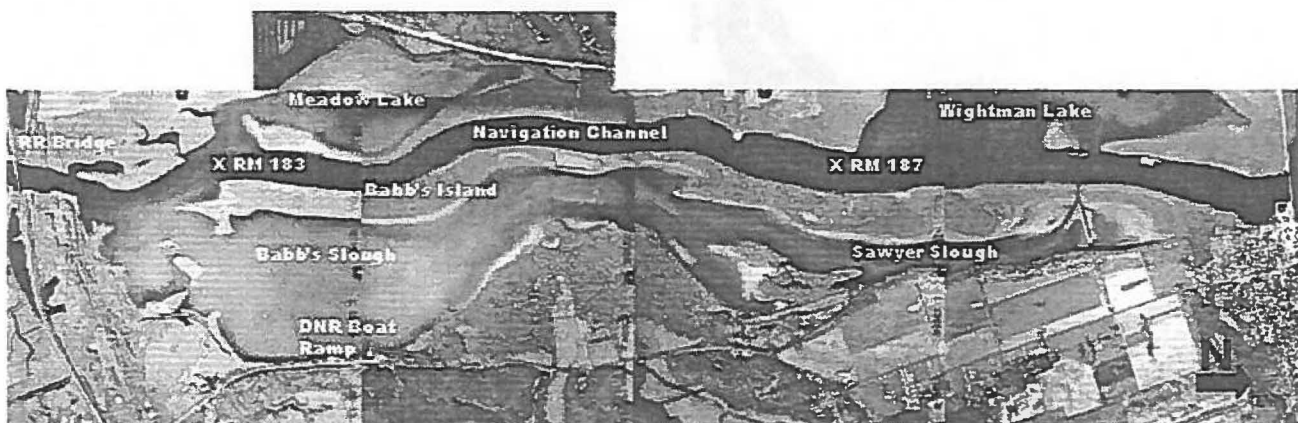


Figure 3. A seven-mile reach of the Illinois River near Lacon, Il in 1994. Most of the water in the backwater lakes is less than a foot deep at normal pool elevation. In 1979 the peninsula labeled Babb's Island was composed of two narrow islands and the entrances to the backwaters were much wider. Mudflats visible at the right (North) end of Sawyer Slough were open water in 1970. Likewise, the land and islands separating Meadow and Wightman Lakes from the navigation channel have substantially widened and lengthened due to sedimentation during the past 32 years.

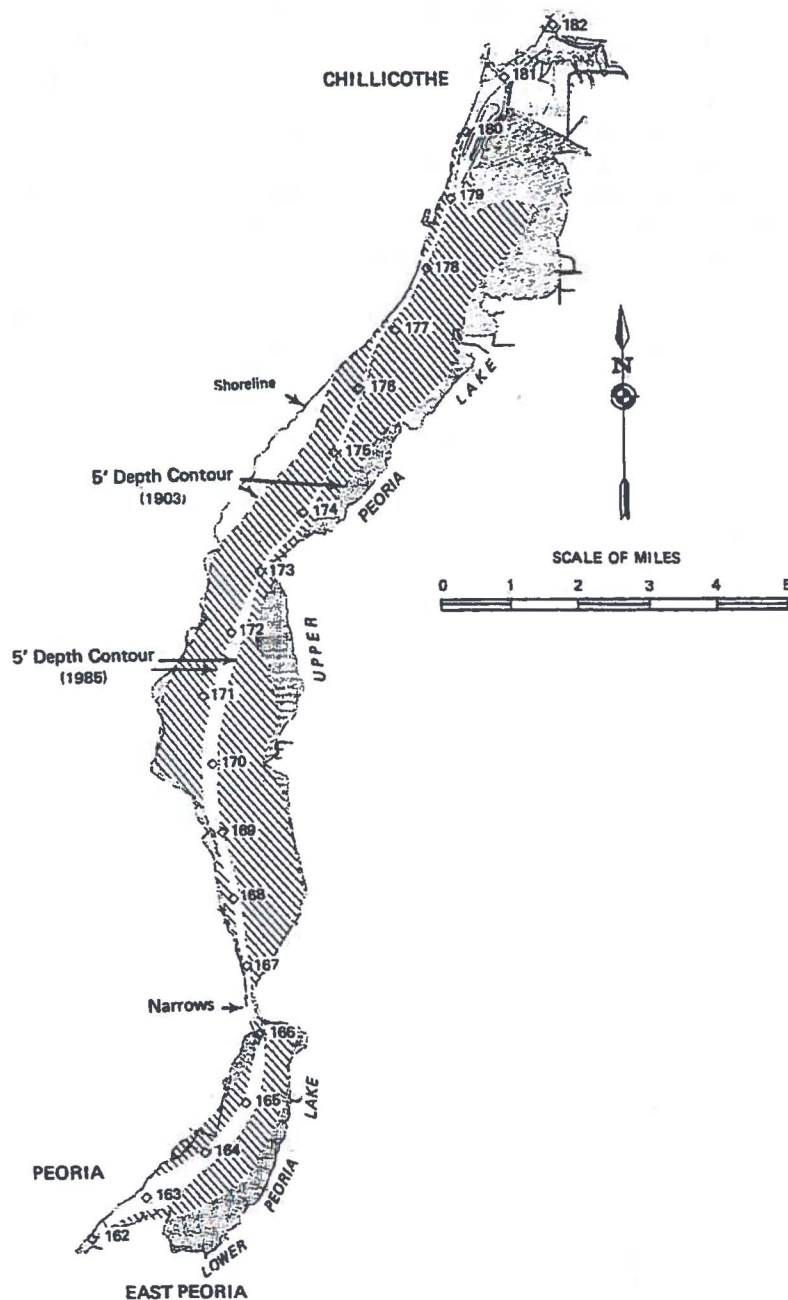


Figure 4. Change in the five foot depth contour (lined area) in the Peoria Lakes between 1903 and 1985. The diamonds are river miles. From Demissie and Bhowmik, 1986.

with less topographic relief.... Biological diversity appears to be declining, and the rate of decline may be increasing," (UMRCC, 1993).

Restoring the Illinois River ecosystem by reducing sediment inflow and selectively removing accumulated sediment are high priorities for the State of Illinois. The restoration is now a partnership effort involving the state, the U.S. Army Corps of Engineers as well as local and regional interests (Bhowmik et al., 2000). Information on the river is being placed on the internet as part of the Illinois Rivers Decision Support System (<http://www.ilrdss.sws.uiuc.edu/>).

Caterpillar Inc and Kress Corporation have worked closely with IDNR on some aspects of the project, especially material handling. This paper will summarize some of the ongoing sediment removal and beneficial use investigations. A number of reports with detailed results are in various stages of the publication process.

SEDIMENT REMOVAL

It is expected that the majority of sediment removed for a restoration project will be material deposited in the pools since 1900. The depth of this material varies from a few feet to over 20 feet on some parts of the Peoria Lakes. Depths of six feet are common. A series of ten cores averaging 6.5 feet in length were obtained over the length of the Peoria Lakes in 1998 (Cahill, 2000). Grain size analysis was performed on 19 subsamples, each about one yard long (one subsample could not be analyzed). The samples were largely silt and clay with only six containing 10 percent or more sand. One, taken near a disturbed site was 44 percent sand. The mean values for various parameters were 6.1% sand, 39.6% silt, and 54.3 % clay. The mean bulk density was 1.5 (range 1.4—1.7) and the percent moisture was 50 (range 37—61). These cores in conjunction with other observations show that recently deposited sediment in the lakes proper is fine grained. However, material deposited on and near the deltas where tributary streams meet the slack backwaters contains high percentages of sand. Material in place prior to 1900 varies greatly. Knowledge of the material at individual project sites will be necessary to properly select equipment and determine possible uses of dredged material, particularly where dredge cuts are deeper than the 1900 profile. IDNR recently acquired a vibra core capable of taking a ten-foot core. It is mounted on a shallow draft pontoon boat and will be used to investigate sediment composition, depth and chemical content.

A range of sediment removal options will likely be required for Illinois River restoration. The methods used will depend upon a number of factors including available funds, dredged material placement site availability, location of needed habitat renovation sites, and the ability to reuse the sediment. Some areas such as Lower Peoria Lake are highly urbanized and have few nearby placement sites for large quantities of material. Other locations in numerous wildlife areas may need relatively small amounts of dredging to provide depth for fish over wintering, but lack adequate space for traditional dewatering of hydraulically dredged material. Another potential limitation is the fact that most backwaters are less than two feet deep most of the year, making access difficult without digging long channels. Additionally, if truly large quantities of sediment are removed, placement out of the floodway will be essential to prevent increasing flood heights. Building a limited number of islands or elevated areas on the floodplain would restore some of the terrestrial topographic diversity that existed prior to 1900. The island option was suggested by state researchers over a decade ago (Demissie et al. 1988). While hydraulic dredging will likely be the best option for some applications, the availability of high solids options would make some of the desired restoration more feasible. For this reason the Illinois Department of Natural Resources (IDNR) and its collaborators are looking onto a range of options, some of which will be discussed below.

Natural islands on the river system are relatively long and narrow, and constructed islands should probably be similarly shaped. If the islands are to consolidate rapidly, clamshelled or high solids dredged material will be desirable. This concept was demonstrated by the Corp's Rock Island District with an Environmental Management Program project (EMP) in Upper Peoria Lake in 1994. The project created a channel for fish habitat about a mile long using a clamshell bucket on a long boom. The top layer of sediment consisting primarily of silt and clay sized particles was cast to the west forming an island about two feet above the normal pool. This "unsuitable overburden" island was expected to wash away. See figures 5 and 6. Deeper material, including sand from the original bottom, was placed to the east at an elevation about six feet above pool height. Nothing other than vegetation was provided to protect the islands from erosion. The main island is 1.1 miles long and has an area of 16 acres and is vegetated. The smaller island is still in place, although it has suffered somewhat from the effects of wave erosion. It is largely unvegetated and protects the larger island from waves during all but high water. In order to provide a firm base, the island was built on a site that was slightly elevated on 1903 maps. This project demonstrated that excavated sediment could be used to build islands, although foundation and erosion protection questions remain regarding their construction at other sites. The major short coming of using the traditional clamshell for much of the restoration is the limited reach of the crane boom and in most cases the need for six or more feet of operating depth.

Clamshells

The ability of conventional clamshell buckets to remove Peoria Lake sediment at *in situ* moisture content is well established. IDNR arranged for a CableArm™ bucket to be demonstrated on a marina access dredging project

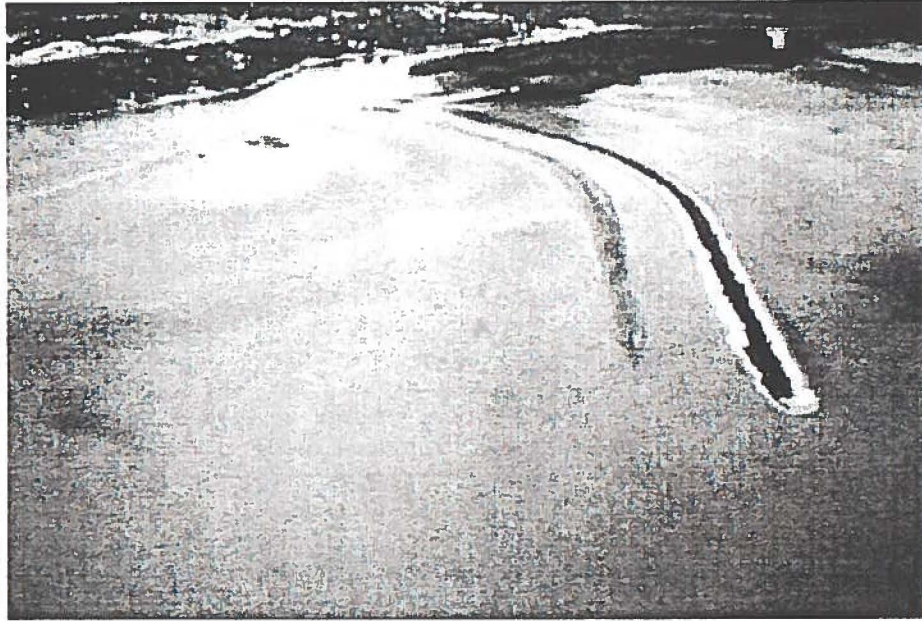


Figure 5. Two EMP islands in Upper Peoria Lake four years after being constructed with a clamshell bucket. The island to the east (right) is about six feet high and supports vegetation. It was built with deeper sediment and contains some sand from the original bottom. The west island is composed of soft sediment and was originally about two feet high. The navigation channel is at the top of the picture. This part of the lake is about 1.5 miles wide and approximately a foot deep.

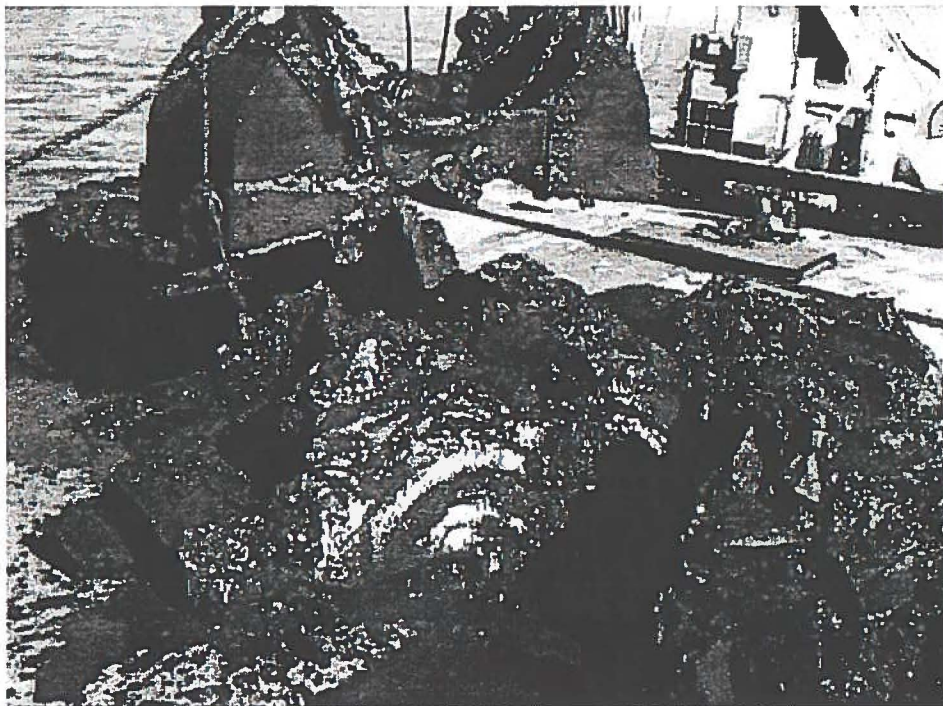


Figure 6. Sediment deposited in Upper Peoria Lake since 1900 is generally stiff and has the consistency of cookie dough. The sediment in this picture was used in the conveyor demonstration within three hours of excavation.

where only soft sediments deposited during the past century were being removed. The bucket performed well and the operators said it was easier to use in this sediment than the conventional one. As expected, the CableArm™ bucket was unable to excavate the compact soil beneath the recent sediment layer.

During high water in June of 2001 a conventional clamshell bucket was used to excavate material in Upper Peoria Lake where water levels do not exceed two feet at normal pool elevations. Excavated material was placed on the small EMP island as well as in the water on the windward and lee sides of the islands creating two tiny islands. Within a week of the water level returning to normal, researchers could walk on the excavated material including the new islands.

Positive Displacement Pump

One potential solution to the boom length concern is to use a positive displacement or concrete pump to transport excavated sediment through a pipe without adding water. The patented DryDREdge™ is purposely built for this function. IDNR arranged a demonstration of this technology in Upper Peoria Lake near the EMP islands in the spring of 2001. The dredge was delivered to the area on a lowboy trailer, placed in the river with a crane and pushed to the site with jon boats. Once on site, the dredge maneuvered using walking spuds and its excavator arm. Water levels at the site fluctuated and occasionally were slightly less than two feet. The dredge used a sealed clam bucket on the end of an arm to fill a hopper feeding the pump.

The demonstration involved excavating soft lake sediment and pumping it through 120 feet of pipe. The operator was instructed to minimize the amount of free water entering the hopper and mixing with the sediment in order to stay as close as possible to *in situ* moisture content. The dredge placed material at several locations on the overburden island and in shallow water. The material exiting the pipe was quite stiff and had no free water. Sixteen samples were taken which showed the dredged material had essentially the same moisture content as the *in situ* sediment. The discharged material was much more firm than expected. See figure 7. It made piles with a slope of about 9:1. When an attempt was made to fill a wooden form 18 inches high and 8 feet square, the material stacked up to the height of the pipe lip instead of flowing across the form like concrete. Material placed at various elevations on the island desiccated rapidly.

The dredge successfully filled four 15-foot circumference geotextile tubes, which when full were about a foot above the normal pool. The discharge pipe was placed inside the tube ports and filled them without discharging any free water. The tubes were placed in a trapezoidal pattern to create a small island with side dimensions of 70, 40, 50 and 40 feet. The pipe was then placed over the west tube and sediment was pumped into the enclosure. The only difficulty encountered was that the sediment did not flow all the way over to the east side. In order to fill the east side of the small island, water was then added to the hopper to thin the discharge and increase the flowability.

The small geotube island was filled on May 2 and monitored for the rest of the year. Figure 8 shows the island on May 12 by which time researchers could walk on 18-inch plywood boards placed on the sediment. On May 30, the island's center had a hard crust that was easily supported researchers. The island was covered by floodwater during most of June. On June 30 after the water receded, the crust was too hard for penetration by the vane shear. Observations and physical measurements taken during the tests near the EMP islands will be published after additional monitoring is completed in 2002.

The dredge delivered sediment at *in situ* moisture content without creating a turbidity or runoff problem at the discharge. It is capable of placing sediment onto islands or shore and could be used to directly fill trucks or barges. It should be able to move Illinois River sediment over 1500 feet without a booster. The existing DryDREdge™ has a capacity of 40-50 cubic yards per hour. It is possible to use a separate pump and clamshell to achieve the same effect. Additionally a larger self-contained dredge could be built. Positive displacement pumps capable of handling over 500 cubic yards per hour are on the market.

Conveyors

A conveyor belt in conjunction with an excavator or clamshell could greatly extend the distance over which excavated high solids dredged material can be transported. The excavated material would lose some strength at transfer points, but could be delivered to an island building or dewatering site in relatively good condition compared

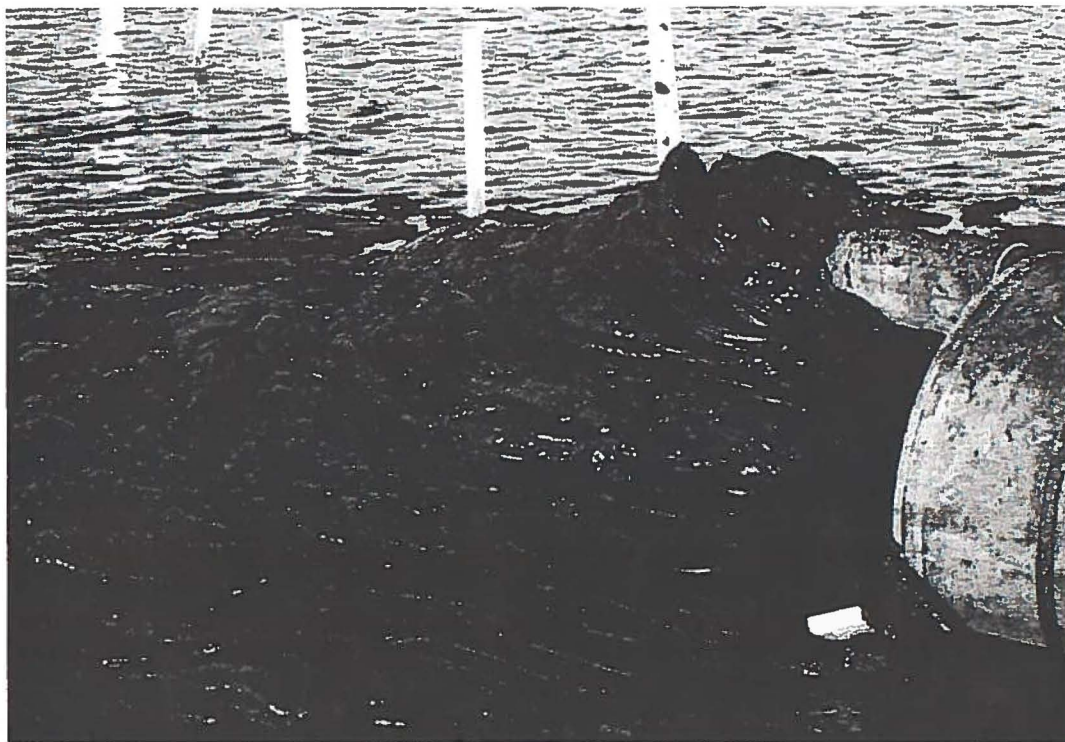


Figure 7. Sediment discharged by the DRY DREdge™ in upper Peoria Lake maintained its original moisture content and readily formed piles with about a 1:9 slope. The dredge uses a positive displacement pump to move clamshelled material.



Figure 8. Engineers taking measurements at a demonstration island three weeks after it was constructed using soft sediment in Upper Peoria Lake. To the right is a small geotextile tube used to protect the island from waves and hold the sediment in place while it consolidates. The sediment was excavated and pumped with the DRY DREdge™ at about 40 cubic yards per hour.

to most other options. A floating conveyor could deliver sediment several hundred feet to an island building site without a transfer point. Issues surrounding this potential method include the consistency and stickiness of the sediment, its moisture content and grain size as well as the stability of the floating conveyor. Floating conveyors over 2000 feet long are used in the sand and gravel industry, and presumably could be designed for use on the Illinois River backwaters.

IDNR arranged a test in the spring of 2002 where sediment freshly excavated with a ½ yard clamshell was placed on conveyors at a sand pit with river access. A ten-foot deep layer of sediment was excavated at *in situ* moisture content from Upper Peoria Lake and carried on a deck barge a distance of about eight miles through rough water. The sediment held its shape during the trip. It was then placed directly on a 36-inch conveyor belt with the onboard clamshell. The sediment traveled about 50 feet and dropped seven feet through the first transfer point, was conveyed 100 feet up a six percent slope, and then transferred to a 50 foot stacking conveyor with a 25 percent slope. A variety of conditions were tested including dropping sediment on a moving belt, wet and dry belts, and with extra water added. In a separate test, an end loader bucket carried sediment to a 600-foot conveyor. The sediment was conveyed that distance without transfers and stopped on an incline. The material kept its shape and did not slide down the belt. The conveyors ran at 410 feet per second. Four video cameras recorded the tests from different locations.

The conveyors and transfer points used in the test were configured for sand, which has significantly different physical properties than fresh sediment. As expected there was some drag back of sediment, as it dropped off the end of dry belts. However, at the first transfer point most of the material fell onto the second conveyor after hitting a baffle. At the second transfer point most of the material missed the stacking conveyor hopper. This material was later collected by an end loader and placed directly into the stacking conveyor hopper. That conveyor was then started and entire load was successfully conveyed up the 25 percent slope.

The sediment maintained a reasonably solid consistency over the belt idlers and across the transfers. It did not liquefy. Minor slumping occurred on the belt, but the sediment cross section remained constant on the belts. The sediment did not exhibit excessive stickiness or build up on the belts or chutes after eight runs. The use of belt scrapers and transfer points designed for the sediment could address the issues of splatter and drag back by the return belt. The sediment traveled an incline greater than that likely in a local dredging project. The test demonstrated that the sediment could feed out of a loaded hopper or a hopper designed to feed sediment at a uniform rate. Figures 9 and 10 are photographs taken during this demonstration.

The pipe conveyor, which folds the belt over on itself, may have applications in sediment transport. It completely encloses material and handles curves.

Slurry Pumps

High solids slurry pumps may prove useful in transporting sediment with lower water content than traditional hydraulic dredges. Such pumps have successfully filled geotextile tubes on several projects in the U. S. where a clamshell bucket placed sediment into a hopper feeding the pump. At several locations including, Tampa and Jacksonville, Florida, barges filled with clamshelled sediment are regularly emptied with these pumps. These pumps have great promise for transporting sediment to areas where it will be confined and there is limited space for dewatering. The Eddy Pump TM is another potential candidate.

Mechanical/Chemical Dewatering

Another option for delivering high solids over a distance is mechanical and chemical dewatering. A high speed mechanical dewatering system developed by J. F. Brennan Co. Inc. in conjunction with Phoenix Process Equipment Co. and Nalco Chemical receives slurry from a hydraulic dredge, passes it through a thickening tank where a polymer aids in settling, and then uses a belt press to remove more moisture. At a project in Iowa visitors observed dredged material leaving the belt press and being immediately collected by an end loader and piled or loaded into trucks. According to Brennan, the system can discharge sediment in the range of 40 percent solids by weight from the thickener and about 65 percent from the belt presses. This type of system could carry sediment several miles prior to dewatering. If the belt press were removed the system could discharge high solids slurry directly to a confined area for island building or drying. Black and Veatch Special Products Corp. has another system.



Figure 9. Peoria Lake sediment after a 600 foot run on a 36 inch conveyor belt. The material was excavated with a clamshell, barged to the site, clamshelled into an end loader bucket and placed on the belt within three hours of excavation. The sediment maintained its cross section during the run.



Figure 10. Peoria Lake sediment passing through a transfer point at a sand pit. The conveyor system was designed for sand and no modifications were made for the sediment. The material did not liquefy or build up excessively on the belts or chutes. Belt scrapers and transfer points could be specifically designed for sediment.

Geotextile Tubes

Geotextile tubes filled with sand are common along the Gulf coast. At several recent large projects they have been filled with silty material or even peat using a variety of equipment including hydraulic dredges. The Drake's Creek Project in the Corps of Engineer's Nashville District and the Fox Waterway Agency's restored island in northern Illinois, are two examples. The tubes are long narrow bags from 15 to 60 feet in circumference that when filled are three to seven feet high. They can be used to dewater material on shore, as breakwaters, or in place of rip rap to protect islands or levees. As discussed above, they can be installed in shallow areas like backwaters without dredging a deep access channel. Unlike riprap and berms built with sediment, they are not likely to wash away. The tubes could be placed in a variety of patterns to increase habitat diversity. Plants can also grow through the fabric or slits in the bags. An island could be elevated by placing a bag on it, filling it and then cutting away the fabric after the sediment consolidates. The long-term effect of UV light and vandalism are two concerns. Damage caused by the latter can usually be repaired with patches that work in both wet and dry conditions.

Buried Object Detection

Project site selection and dredging efficiency can be enhanced if the nature and location of objects buried in areas to be dredged are known. Armed with a subbottom map, planners could decide to avoid siting projects in areas with many targets and to either remove or bypass objects such as sunken logs, cars, cables and barges. IDNR and its collaborators have worked with a number of contractors and conducted preliminary tests. A number of technologies were used including GPS equipment, ground penetrating radar, magnetometers, sonar and electromagnetic induction. A non-metallic towed sled capable of operating above or below the surface was developed. It has a mast for holding the GPS antenna above water. A shortage of funds has temporarily halted this effort.

Hydrodynamic Model

The construction of islands or other features in the floodplain or backwaters can alter flood heights, velocity, and sedimentation patterns among others. The IDNR's State Water Survey developed a hydrodynamic model of the river between Peoria and Henry. The details of this effort will be included as part of the Corps of Engineers' documents on the Illinois River projects and in formal reports. (Bhowmik and Demissie 2001). Researchers used the RMA2 model of the Surface Water Modeling System (SMS), a two-dimensional finite element model in plane coordinates. Inputs included hydrographic data, newly collected elevation data and river discharges. The model was calibrated and verified utilizing measured stages and several high and low flow events.

The model will assist in determining appropriate locations for project features and gaining insights into their potential effects. The model will simulate islands constructed in various shapes, orientations and sizes. Its output will help assess potential changes in velocity and predict locations where scour or deposition may occur as well as the need for protecting the island from the erosive forces of the current. The information will also be useful in determining potential impacts on nearby bridges, shorelines and the navigation channel.

BENEFICIAL USE OF SEDIMENT

Given that the Illinois River backwaters contain several hundred million cubic yards of sediment and accumulate several million more annually, sediment removal and reuse necessarily require large-scale options. A solution will most likely consist of a variety of measures implemented over a number of years, including major emphasis on preventing erosion. The sediment accumulated over a century, so a multi-decade timetable is reasonable. Promising potential uses include island and elevated habitat construction, spreading on nearby farmland, use as landscaping soil, and off floodplain storage for future use. Smaller scale options include construction fill, flowable fill, landfill cover, and manufactured construction products such as bricks.

Habitat Construction

The elevated water levels and frequent fluctuations since 1900 have altered the terrestrial habitat on the islands and floodplain. It floods more frequently and has a higher water table. This has contributed to a serious decline of important plants such as floodplain hardwood trees and many associated animals. The selective placement of sediment on the islands and certain floodplain areas will help restore habitat diversity. In some areas this could be

accomplished with hydraulic dredging into bermed areas, but in many locations the shape of islands and other features will require the placement of high solids or dewatered sediment. For example, if several island projects are underway in the same river reach, such sediment could be placed in relatively thin lifts on an island and allowed to consolidate while the equipment is used at a nearby site. Observations on clamshelled sediment placed about 18 inches deep on a field support this concept. Vane shear and push cone penetrometer measurements were taken of material in various stages of handling. The strength of material placed gently on a deck barge was similar to that of the *in situ* material. The average values of sediment peak undrained shear strength dropped from about 0.33 to 0.21 psi and penetration resistance dropped from approximately 8 to 3.1 pounds after the material was clamshelled from the barge into trucks, hauled three miles and then deposited on site. After about ten days on site, the penetration resistance increased to 24.4 pounds in the upper four inches and 10.4 pounds between 6 and 18 inches.

The construction of such features may require the use of geotextile tubes, or other materials to provide containment or protect the material from waves as it consolidates. It is also possible to build perched wetlands on mounds of sediment. A limitation on this option is it may have an impact on floodwater storage and conveyance as well as other habitat types if it is used excessively. For this reason it is not viewed as the sole solution.

Suitability as Landscaping Soil

The vast majority of the sediment in the backwaters is material eroded from Illinois farmland and stream banks and beds. IDNR is investigating the potential for using dredged sediment as landscaping soil. Sediment from various dredging projects has been used informally along the river for decades, but there is little documentation of its effectiveness as soil. A variety of studies of the agronomic value of the sediment are either completed or underway. Researchers at several state agencies, the University of Illinois and Southern Illinois University are conducting the studies and demonstrations. They include plant growth tests, analysis of plants for metals, and field trials among others.

Fields used as placement sites for material hydraulically dredged from central Illinois reservoirs over the past 20 years were studied along with Illinois River floodplain soil and sediment clamshelled from Upper Peoria Lake in 1994. Where possible, cores were taken with a truck mounted Giddings Soil Probe and penetrometer readings were taken. Cores were described by standard methods and a variety of tests were conducted. The results showed that the grain size of the reservoir sediment is similar to that in the river. After dewatering and weathering sediment strength increases to the point where conventional farming operations are possible. Fertility data indicated that the sediments are generally rich in plant nutrients. The conclusions regarding the physical characteristics of the evaluated dredged sediments are that they "are similar to naturally productive, fine textured agricultural soils in Illinois.... There is no indication in the physical data that these sediments should present a problem for agricultural utilization given proper handling, tillage and fertility treatments" (Darmody and Marlin, 2002).

In a greenhouse study (Darmody et al. in preparation), barley and five garden vegetables were grown in Peoria Lakes' sediment and central Illinois topsoil. Seed germination between treatments was not significantly different. While there were some minor differences in growth and yield, the fertility and productivity of the sediment and topsoil were essentially the same. See figure 11.

Sediment clamshelled from Lower Peoria Lake was trucked to two sites where it is periodically observed. In early May of 2000, material was placed approximately 18 inches deep on an old power plant site in East Peoria which is shown in Figure 12. It dewatered and consolidated rapidly and could have been disked within a month. The sediment in the field dried all the way to the original soil level within two months. It was the consistency of plaster and long blocks in the shape of desiccation cracks could readily be lifted out. The blocks gradually weathered. In the spring, after several winter freeze-thaw cycles, the sediment was granular and could easily be turned by hand.

Other material from the project was deposited in a gravel pit where it was unable to rapidly dewater. Volunteer plants colonized both sites. Researchers from the Illinois Natural History Survey visited the sites in September. The field "supported 47 plant species, predominantly weeds of old fields, waste places and agricultural land." The pit "supported 53 plant species, and these were plant species quite common in early successional, disturbed emergent wetlands along the Illinois River." (Memorandum from Allen Plocher). It was not possible to determine the source of the seeds, but the researches believe that the majority of the plants grew from the sediment seed bank.

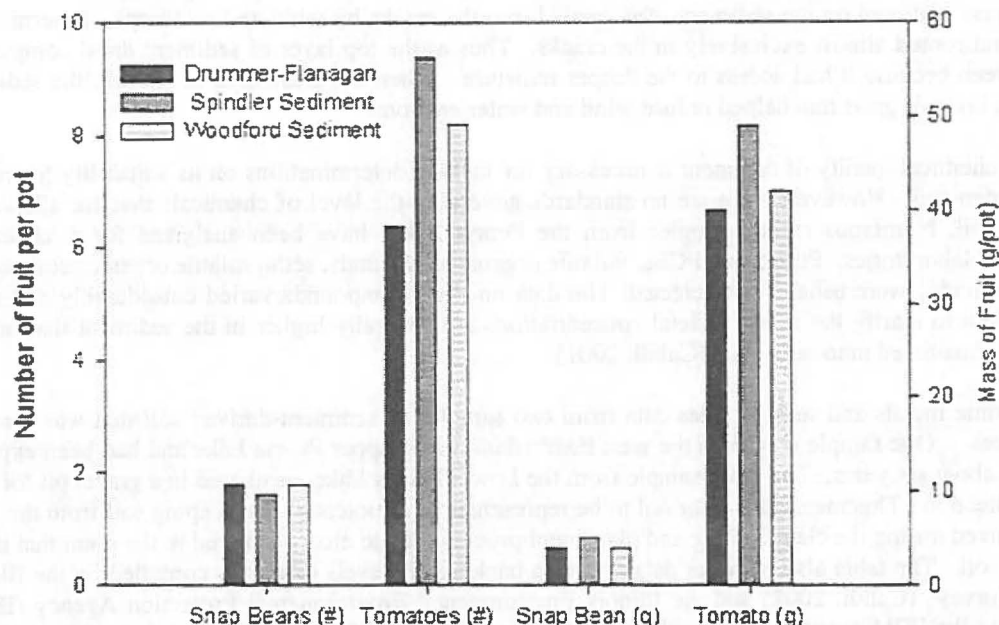


Figure 11. There was little difference between the yield of fruit on plants grown in Peoria Lake sediment and central Illinois topsoil (Drummer Flanagan). Spindler sediment was collected from the river bottom, dried and used without weathering; while the Woodford sediment was taken from the EMP island where it was subject to the elements for the prior four years. Fertility and productivity of the three soil materials were also essentially the same.



Figure 12. Sediment clamshelled from Lower Peoria Lake was trucked to a local field in early May of 2000 (The water in the picture is from rainfall, not the sediment). It rapidly formed desiccation cracks and was workable within a month. In early July a tractor pulverized the dried sediment. Forty-seven species of volunteer plants were growing on the field by October.

Sediment at or near *in situ* moisture content developed desiccation cracks within hours of placement. At several plots annual rye grass scattered on the sediment, was carried into the cracks by wind and raindrops. It germinated within four days and rooted almost exclusively in the cracks. Thus as the top layer of sediment dried completely, the grass stayed green because it had access to the deeper moisture. When the grass died in the fall, the sediment was covered with a layer of grass that helped reduce wind and water erosion.

Knowledge of the chemical quality of sediment is necessary for making determinations on its suitability for use as landscaping or garden soil. However, there are no standards governing the level of chemicals that are allowed in sediment used as soil. Numerous recent samples from the Peoria Lakes have been analyzed for a variety of chemicals by several laboratories. Pesticides, PCBs, volatile organic compounds, semi-volatile organics compounds and chlorinated pesticides were usually not detected. The data on PAH compounds varied considerably and more samples will be taken to clarify the issue. Metal concentrations are generally higher in the sediment than native topsoil, but are not considered unusually high (Cahill, 2001).

Table 1 includes some metals and semivolatiles data from two samples of sediment-derived soil that was dredged from the Peoria lakes. One sample was from the west EMP island in the upper Peoria Lake and had been exposed to the elements for about six years. The other sample from the Lower Peoria Lake weathered in a gravel pit for nine months prior to collection. This material is believed to be representative of potential landscaping soil from the river since it was well mixed during the clamshelling and placement process. It had also weathered to the point that it had the consistency of soil. The table also includes data on mean background levels of metals compiled by the Illinois State Geological Survey (Cahill, 2001) and the Illinois Environmental Protection Agency (IEPA, 1994). According to the IEPA report, "The results were obtained from samples taken in areas, judged by the field staff taking the samples, to be undisturbed and unimpacted by site-related activities."

Potential Large Scale Uses

An ideal use of this dredged material would be as landscaping soil at strip mines, old industrial sites known as brownfields, and highway and other projects. In some areas it could also be placed on nearby farmland that would benefit from its fertility and physical characteristics. If the chemical quality is determined to be adequate, it could be marketed as residential topsoil by the bag or truckload.

The project area is well located to provide landscaping soil to a number of industrialized urban areas. Soil from the Peoria Lakes could be readily shipped by barge to the Chicago area, a distance of 160 river miles. Many Chicago area brownfields directly abut the waterway and are essentially devoid of topsoil. Other urban areas within easy reach by waterway include St. Louis and Gary, Ind. To minimize handling and water weight, sediment could be loaded directly onto barges with a clamshell and taken to a brownfield or dewatering site. A slurry pump could empty the barges and place sediment directly on the fields needing soil. Alternatively a lightweight bucket could load the material into trucks or onto a conveyor for placement. After weathering or disking and turning, the sediment could be placed at the desired location and depth.

The advantages of such an operation are that environmental benefits are obtained at both ends; topsoil does not have to be taken from new subdivisions, scattered construction sites or farmland; the river can provide large quantities of soil with consistent quality, and it does not have to be trucked long distances over urban freeways and through neighborhoods to arrive at most placement sites. Initial projects may involve federal and state efforts to restore brownfields or provide soil to parks. However, if the sediment-derived soil is competitive, a commercial operation could be established to market it. It is likely that a company could obtain permits to remove sediment from selected backwaters without becoming part of a federal or state project.

Other options are taking the sediment to strip mined areas along the river or using it at highway projects. There is a state-owned strip mined area along the river about 20 miles from Peoria, and Interstate 74 at Peoria is about to be reconstructed. This project provides a ready opportunity to develop and test methods for handling and processing sediment and weathering it to a proper consistency. There is another old strip mine about 55 miles to the west near a pipeline corridor. It is conceivable that sediment could be pumped that distance given that it was pumped over 20 miles at the Whiterock project in Texas.

Table 1. Levels of Selected Chemicals in Weathered Sediment from the Peoria Lakes and Background Levels in Illinois Soils (mg/kg).

| Chemical | Lower Peoria Lake* | Upper Peoria Lake* | Statewide Mean Background (ISGS)** | Mean Background Levels in Illinois MSAs (IEPA) *** |
|---|--------------------|--------------------|------------------------------------|--|
| Metals | | | | |
| Arsenic | 6.2 | 7.1 | 10.0 | 7.4 |
| Barium | 110 | 140 | 545 | 133 |
| Beryllium | 0.58 | 0.75 | 1.4 | 0.73 |
| Cadmium | <1.1 | 3.2 | <1 | 1.3 |
| Chromium | 23 | 38 | 57 | 21.2 |
| Copper | 21 | 38 | 30 | 28.9 |
| Lead | 27 | 46 | 24 | 71.1 |
| Mercury | 0.10 | 0.35 | NA | 0.12 |
| Nickel | 26 | 34 | 24 | 20.9 |
| Selenium | ND | <1.5 | <1 | 0.58 |
| Zinc | 110 | 220 | 73 | 137.9 |
| Semi-volatiles | | | | |
| Anthracene | ND | 0.09 | NA | NA |
| Benzo(a)anthracene | 0.20 | 0.25 | NA | NA |
| Benzo(a)pyrene | 0.22 | 0.34 | NA | NA |
| Chrysene | 0.26 | 0.33 | NA | NA |
| Flouranthene | 0.48 | 0.30 | NA | NA |
| Pyrene | 0.44 | 0.34 | NA | NA |
| * The LPL sample was from material dredged in April 2000 and weathered outside for 9 months. The UPL sample was taken from the EMP island after weathering six years. | | | | |
| ** From Illinois State Geological Survey (Cahill, 2001). | | | | |
| *** The Metropolitan Statistical Areas include counties in the Peoria area as well as Chicago and E. St. Louis. From IEPA, 1994. | | | | |

There are thousands of acres of farmland near the river that are sandy or have depleted topsoil. It would be relatively easy to dredge material directly from the backwaters onto some of these farms. Barge loads could also be placed on more distant farms with slurry pumps, but at greater cost. Sediment is currently in place on a sandy research farm that will be planted in corn and soybeans during 2002. Another option is to store it in large mounds for future use.

Regulatory and statutory changes could help by providing more favorable treatment in cost sharing and other matters for transporting and processing sediment for beneficial use.

SUMMARY AND CONCLUSIONS

Restoration efforts in the Illinois River valley will likely require a range of equipment and techniques. Potential projects vary from moving sediment from large backwater lakes to the high ground, building islands, and selective dredging with placement on small areas of nearby existing islands. There is a need for technology that bridges the gap between conventional crane mounted clamshells and hydraulic dredges. The desired features include sediment transport, rapid dewatering and consolidation, and maintenance of some of the sediment's structural integrity. The ability to place sediment in thin lifts would be particularly useful. Several of the devices and techniques described above could accomplish this alone or in combination. Sediment in the Illinois River backwaters and lakes is essentially topsoil and will support vigorous plant growth. It could be used as a landscaping soil and to restore productivity on degraded land.

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